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Raw, eroding streambanks permit swollen streams to cut deep into fertile bottomland, and add to the silt load.

Willows for Streambank Control

By J. R. Fry, Jr.[1]

THE rugged topography of southwestern Wisconsin, consisting of narrow ridges breaking off in steep slopes to the valleys below, permits rapid runoff of rainwater which endangers the banks of even the smallest streams. One of the problems of Service technicians in this area, and particularly in the Coon Creek project, has been the development of a practical method for protecting streambanks, so as to prevent destruction of fertile bottomland and to decrease the silting and flood hazards downstream.

Sudden, intense thunderstorms are common during the summer months and streams frequently overflow their banks and cause serious damage to adjacent lands. Coon Creek, for example, has a normal flow of 40.3 cubic feet per second and a silt content of 267 tons per day at the Coon Valley gaging station, halfway mark between the headwaters and the mouth. In flood stage it has had an instantaneous flow of 8,110 cubic feet per second and a silt load of 36,800 tons per day. Under these flood conditions streams cut deep gashes into rich bottomland fields and pastures, often ruining the land for cultivation and adding greatly to the silt load, especially where streambanks are left unprotected.

Since the spring of 1934 various vegetative and mechanical methods have been employed in the Coon Creek project to protect streambanks. Live willows have been used in a number of ways with varying degrees of success. No difficulty has ever been experienced in getting the willows to sprout and grow under favorable conditions, but it became evident as the work progressed that the growing willows require protection from flood waters until they be-

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After sloping the bank, willow poles and brush matting have been laid to prevent further cutting. The rock-toe wall protects the matting until willows become established.

come well established. Brush-rock wing dams, piling, timber cribs, and bulkheads furnished this structural protection, and willow slips were planted successfully on the downstream side of the structures. However, this necessary precaution greatly limited the use of willows in streambank work. Another method was needed that would incorporate mechanical protection with the willow planting itself.

After 2 years of trials a method has been developed that has proved very effective and may now be considered for more extensive use. The eroding streambank, which generally is raw and vertical, is first given a 1:1 slope, and most of the loose earth is piled above the sloped bank. At 4- to 5-foot intervals shallow trenches are dug from the water's edge to the top of the bank. Willow poles are placed in the trenches with the butts forced into the muck beneath the water level and the poles extending the full height of the sloped bank. The trenches are then filled with soil until only the upper third of the pole for its full length remains exposed, after which the poles are securely fastened to the bank with willow stakes and No. 9 smooth wire.

The exposed portion of the bank between the poles is thatched, from slightly beneath the water level to the top of the bank, with bundles of willow brush. The effect is much like that of shingles on a roof. Care must be taken, however, to avoid covering the partially buried poles, since this would seriously limit their ability to sprout. The brush thatching and poles are next covered with one or two widths of hog wire laid at right angles to the willow bundles. The hog wire is tied to the bank with willow stakes and No. 9 wire. Poles are sometimes laid over the hog wire, and at right angles to it, as an additional safeguard. These poles are likewise tied to the bank with willow stakes and No. 9 smooth wire. The toe of the bank should be riprapped with rocks to prevent the stream from undercutting the brush matting. Finally, the loose earth piled above the bank is scattered over the willow bundles to fill up the air spaces and maintain the moisture necessary for sprouting.

A streambank treated in this manner receives immediate mechanical protection in the riprapping and brush matting. Within a short time the partially buried poles, willow stakes, and brush matting all produce sprouts which become progressively more capable of withstanding flood waters. At the end of the second growing season the shoots average about 6 feet in height and are well able to take care of themselves without the aid of the decaying portions of the brush matting.

A simplification of the foregoing construction method shows considerable promise and will undoubtedly result in lowered costs. The brush matting has sprouted so profusely that it is believed possible under certain conditions to eliminate the partially buried willow poles. When the height of the sloped bank does not exceed the length of one tier of willow bundles, the initial series of poles seems to be unnecessary, since sufficient sprouts may be expected from the matting alone. It may also be possible to eliminate either the hog wire or the poles which surmount it. In the event that the hog wire is excluded,

Under control. The willows have made enough growth in 2 years to afford permanent protection to streambank. They also reduce silting, increase fish food, furnish splendid coverts and travel lanes for wildlife.

poles must be run at right angles to the bundles to hold down the brush matting. Riprapping the toe of the bank with stone is an essential safeguard, however, and should not be neglected.

Almost all species of willow common to this area have been used successfully in streambank work. Sandbar willow (*Salix longifolia*) has been employed most extensively because it has been most readily available, and has been very satisfactory in every respect. It is of prime importance that a "brush" type of willow be used in this work, although this, of course, is not always possible when willow poles are expected to furnish part of the growth. "Brush" willows grow very densely and from a compact mass of comparatively small roots which effectively bind the soil to the bank. Because they never develop into tree size, they maintain their density and do not shade out other willow shoots. Their small diameter enables them to bend over during a flood and thus form a protective thatching over the bank. In this area they have not lowered the capacity of the streambed by encroaching upon the stream, and they are easily controlled in fields by cultivation.

Since willow matting and brush-rock wing dams may often be used interchangeably, it is desirable to compare the two methods. The costs of willow matting and wing dams are about the same per linear foot of streambank protected. With the simplifications suggested, the costs may be in favor of the brush matting.

Streambank planting must be protected from livestock damage by fencing or some other means. It is not essential to protect wing dams; if they are to become permanent living deflectors, however, they must contain willow brush capable of sprouting, in which event they would require protection. But even protected wing dams may not need as much fencing as long stretches of willow matting.

Wing dams may be constructed any time of the year, although they are commonly built during the winter when other work is impossible or impractical. Willow matting may be laid whenever the willow is in a dormant stage. Equally good results have been obtained from fall and spring construction. If much bank sloping must be done, willow matting usually will have to be laid, for economy's sake, when the ground is not deeply frozen. This is not the case with wing dams which, to ensure permanency, should be built when the willow brush is dormant.

Willow matting is of somewhat less complicated construction than are wing dams, and no technical training or experience is required to determine its location. The matting merely protects the bank, enabling the stream to follow its normal course with little deflection. The principle of wing dams, however, is to deflect the current away from the eroding bank, and the altered current sometimes starts cutting the opposite bank, thus necessitating another structure.

In addition to affording excellent natural protection for eroding streambanks, willow thickets along stream-

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Erosion and Drainage

By J. Frank Relf[1]

"The most instantaneous and effective of all fresh water reservoirs is the soil."—*Allen Hazen in Flood Flow, page 154. New York. 1930.*

TODAY it is apparent that one of the menaces of our great Corn Belt (loessial soil region) is the approach to a complete drainage of the rolling tableland by surface and subdrainage, much of which is caused by erosion. Streams that formerly flowed continuously now are intermittent. Many wells which once provided abundant fresh water have been lowered or have failed. Crops suffer more during prolonged periods of abnormally low precipitation than when the land was new. Yet climatological data, recorded over a long period of years, indicate little change in the yearly precipitation of the area.

During the period from 1909 to 1912, in the Nemaha Valley, which runs through northeastern Kansas and southeastern Nebraska, large open drainage channels were constructed to drain off floodwaters after heavy rains. Formerly these waters flooded the valley for a week or 10 days, but now they drain off through the new open channels in 24 to 48 hours. The open channels have provided an outlet not only for the floodwaters but for the surplus water on or in the soil as well, and as a result, 71,300 acres of rich wet overflow land are well drained by the system. The groundwater table that formerly stood at or near the surface of the valley has been lowered by subdrainage. This is a good example of drainage of the soil by open channels.

Our vast rolling tableland with gentle sodded valleys has been eroded and dissected into small areas (residual bench areas) by a checkerboard highway system and numerous gullies which branch out from the parent streams. The highways and the gullies form a drainage system that aids gravity in draining the surface and ground water from the adjacent areas in a short time.

Changes in southeastern Nebraska will illustrate drainage as resulting from highways and erosion. In the comparatively short period of 65 years the trails running directly from one trading point to another were replaced by a system of highways. Gullies advanced from the two parent streams through each valley. Today the road channels and numerous gullies provide an easy and quick drainage.

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[1] Associate agricultural engineer, Soil Conservation Service, Stillwater, Okla.

The Story in Pictures

1. A great cavity 27 feet deep, 57 feet wide, branching off from the main gully and advancing up through a gently sloping cultivated field. The overfall has crossed the public road and crept into the field within the last few years. A temporary bridge is back in the field. Small springs and seepage flowing from the base cause the vertical banks to cave in. Water flowing over the overfall will soon dissolve the caved-in soil and carry it down the gully to add to the fill in some stream. Surface and subdrainage are greatly accelerated in this field, as compared with the sod-held valley shown in picture 6.

2. A 30-foot bridge over a 23-foot gully, in Nebraska. During a dry period in 1936 when small plants in the cultivated fields were badly needing moisture, ground water was seeping out of the base and flowing down the gully, as shown here. Continuous drainage will soon lower the water table in the adjacent field.

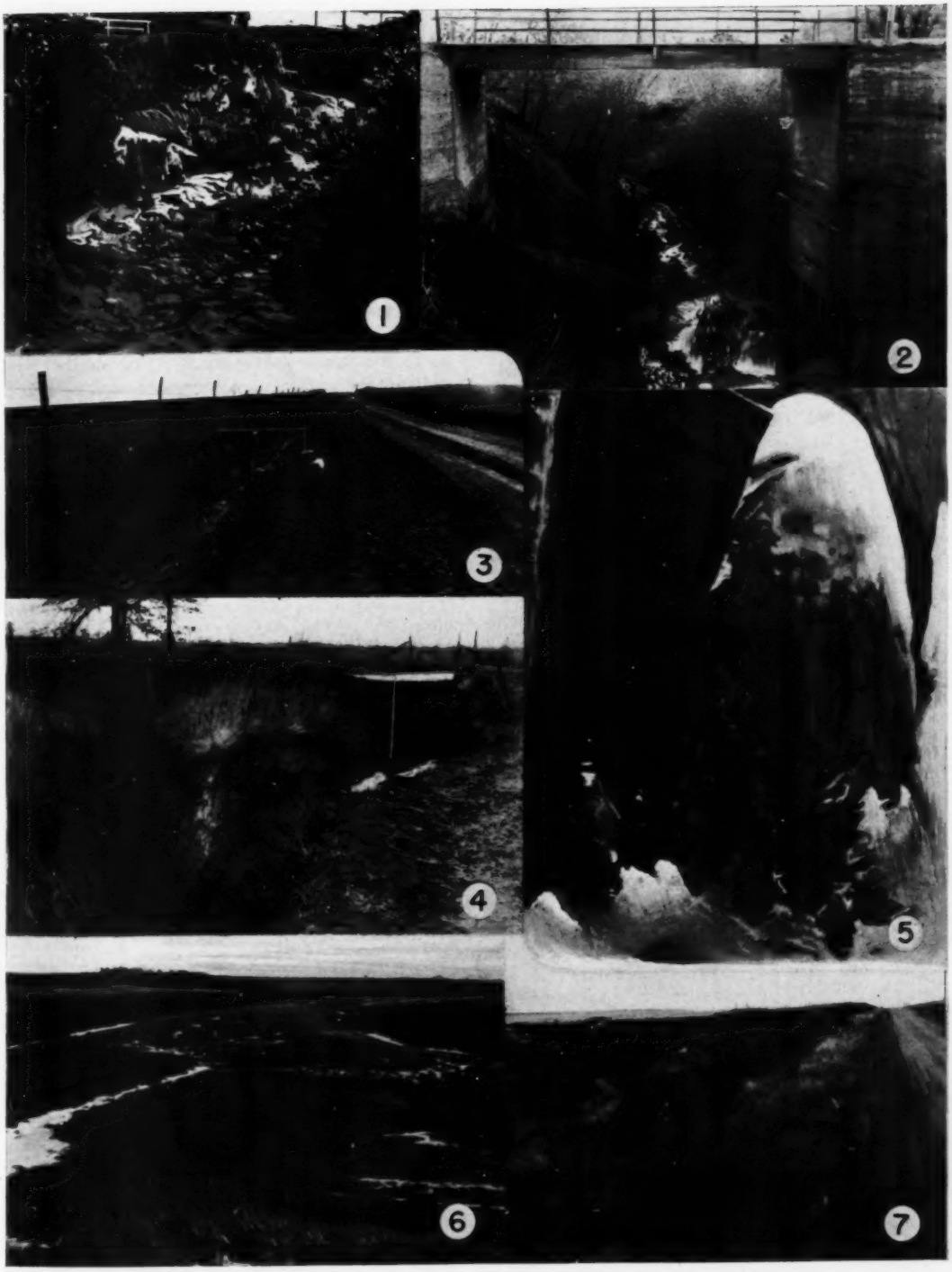
3. Well-graded roadbed running uphill, a typical example of many graded roads in the rolling tableland. Usage and erosion have removed considerable quantities of soil from the disturbed area. The road channel where the man stands is 4½ feet below the surface, while the shoulder of the road grade (marked by the stake) is 1.8 feet below the surface of the adjacent field. Water falling on the field sloping toward the road, and that which falls on the road, will be quickly removed by drainage to a channel or gully at the base of the hill. The exposed bank along the fence line will lose considerable moisture by evaporation.

4. This advancing gully now has an overfall 11½ feet deep at the edge of the concrete slab. It will soon take the public road and continue upward, to menace the adjoining field.

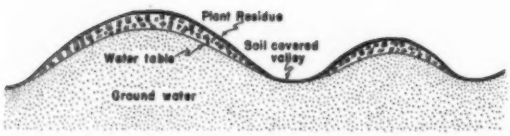
5. A huge icicle on the side wall of a vertical inlet to a culvert. A smaller icicle resulted from seepage through a weep hole in the lower left corner. The culvert is located in a gully 37 feet deep. Freezing of the ground surface and covering with snow obviously did not stop subdrainage of the area.

6. A sodded valley between two cultivated fields tends to hold the run-off water and silt. The water flowing on to the area at the lower left was retarded and spread out over the entire lower portion of the sodded valley without erosion during the February 1937 thaw, while unprotected valleys and gullies were accelerating the run-off and eroding very badly at the time.

7. The gully at the left started from a small road ditch. It is working up the hill alongside the road and gnawing gradually into the sloping field at the left.



(Captions on opposite page)



Loess soil profile in 1857, showing relationship of water table to surface of soil. Water then sought a level near or at the surface in the valley, some depth below the surface on the hill.

(Continued from p. 112)

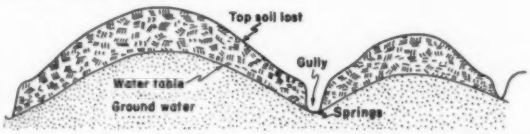
The drainage of the township as it was 65 years ago allowed run-off water to travel long distances over well vegetated valleys, while the excess ground water found outlets through the numerous springs along the parent streams. The retarded movement of run-off water over a highly absorptive soil permitted a large amount of water to percolate into the soil, thus providing an abundant supply of ground water for plants and streams. It is no wonder that the area now shows the effects of drought during periods of low precipitation. Erosion has removed a large percent of the topsoil, exposing a tight and more compact soil that is susceptible to excessive run-off. Gullies and road channels surrounding each small area receive the run-off and carry it rapidly to the major streams. Water that should be retained in the ground where it falls is lost.

Drainage consists essentially in the direct removal of surface and ground water from the soil. An open channel, whether natural or artificial, provides free passage for surface and ground water. Hence, a gully or road ditch is simply a means of aiding gravity in removing run-off and stored ground water. The free passage of ground water into a gully (subdrainage) may lower the water table or deplete the supply stored in the soil to the extent that vegetation will suffer during dry seasons.

On the other hand a well-sodded valley retards surface and subdrainage, thus allowing a greater supply of water to be stored in the ground for plant and domestic uses. The run-off from intense rainstorms is carried gradually to the parent stream, thus reducing local floods, while the excess ground water drains gradually through the porous soil and crevices to springs which in turn feed the larger streams with a constant supply of clear water.

In addition to an ample supply of ground water, the sod-covered valley retards the surface run-off to the extent that in many instances the fertile valley is not suitable for agricultural crops because of the excess water. However, it usually makes good pasture or hay land.

Intensive farming practices led the farmer to plow up the valley and drain off the excess water by drawing a furrow down through the valley to an outlet. The highway official, to maintain a dry roadbed, cut a ditch on each side of the road grade for speedy removal of all water falling on the road and the run-off from the adjacent field. Water flowing through the little furrow in the valley or the road channel down the hillside soon developed an overfall which in a comparatively short time worked back through the valley, producing a gully often 25 to 35 feet in depth. The farmer and highway official were little concerned at first about the advancing gully as it was an aid to gravity in draining the wet farm land and the highway. Later, however, they became deeply concerned as the main gully deepened and widened with numerous fingers branching out from each side and advancing rapidly up the slope to dissect the field into small residual areas or to destroy the entire area.



The profile 65 years later. Wasteful usage has removed a large part of the rich topsoil. A gully of considerable depth has aided gravity in draining the valley of both surface and ground water. Increased slopes and compacted soils have increased and accelerated the run-off. It is reasonable to assume that the ground water in the adjacent high lands is also being lowered or depleted.

An examination of many of the gullies in the loessial region reveals springs or seepage flowing out of the banks near the gully bed. Many of the springs or seeps flow continuously throughout the year subdraining the soil of its supply of stored ground water. The water table that was near the surface has drained down until it stands several feet below the surface of the valley—this due to surface and subdrainage by gullies and road ditches. It is reasonable to conclude that the whole water table in the area adjacent to gullies also has been lowered and the partial supply of stored ground water is now insufficient for plant and animal life during abnormally low rainfall. Furthermore, the accelerated run-off from the residual field to the nearby gully or road channel is carried quickly to the major stream, adding materially to periodical floods.

TENTATIVELY SCHEDULED

January—*Engineering*

March—*Wildlife*

FARMING LEVEL TERRACES IN THE DUST BOWL

By Fred C. Newport [1] and Robert R. Hinde [2]

MANY of the early attempts at soil and moisture conservation were centered in the eroded plains east of the southern Great Plains and in some of the southern counties of the Texas Panhandle. Although definite dates are lacking, it seems probable that both level terraces and contour tillage without terraces were tried by different individuals in some parts of the area as early as 1918. For the purpose of this paper, however, the history of level terraces began in the southern Great Plains region on two State experiment stations, one located at Goodwell, Okla., and the other at Spur, Tex. In 1926 the first crops were harvested from land under treatment on these two stations.

Data from the Panhandle Experiment Station at Goodwell show that the yields of wheat and sorghum are increased by level closed-end terraces on a Richfield silt loam soil. This experiment station is in the southern Great Plains region where the average annual rainfall is 17.48 inches.

These studies were conducted on a series of alternately terraced and un-terraced plots. The plots were so established that moisture readings could be obtained on terraces spaced from 40 to 350 feet. The plots were 350 feet in length, running down the slope which averaged 0.7 percent, and were diked on all sides to prevent run-off and the encroachment of water from adjoining areas. The plots were one-fifth of an acre in size.

The Spur Station in Dickens County is located in the rolling plains region of northwest Texas, on Miles clay loam soil. Data show that the average annual rainfall at the station is 21.36 inches, 85 percent of which falls during the growing season for summer crops, and that of the total rainfall received 20 percent occurs in light ineffective showers while another 20 percent is lost by run-off. This leaves only 60 percent to be absorbed by the soil for crop production.

The studies indicate that tremendous water losses occur on areas with very little slope. Crop yields from the field areas show that in general water can be saved by contoured rows, level closed terraces and dikes, and that the yields of crops are in proportion to the amount of water saved.

Cropping level terraces in the Dust Bowl may be considered as an attempt to use efficiently the moisture that has been stored before planting time or which may be encouraged to soak into the ground during the growing season, to ensure proper growth of the best adapted crops and to provide enough litter therefrom to protect the land against wind erosion. For these purposes, let us apply the mechanical and vegetative

End-closure and terrace base producing milo. Terrace interval seeded to wheat parallel to the terrace.

1.

methods of soil and moisture conservation to a terraced field with respect to, first, the terrace ridge and end-closure, second, the terrace interval or space between terraces, and third, the irregular interval between terraces—the point-row interval.

Before the terrace ridges and end-closures are planted to any crop, considerable study should be given to the condition of the soil in the surrounding fields. If the lack of organic material seems to indicate blow conditions, these structures should be planted to some fibrous-rooted crop such as sorghum, preferably close drilled. The barrow pit on each side of the ridge is an ideal place on which to plant milo or forage sorghums. This gives an opportunity to open the land where wheat is grown without the "drive over" loss of wheat, and also it helps to reduce the hazard of lodging in wheat fields along the terrace ridges in case of excess rainfall during harvest season or immediately before. Should the terrace ridge and end-closures be too narrow and steep for seeding, rows of crops may be planted for protection against soil movement. These strips may be wide enough on each side of the ridge to allow for widening of the terrace ridge without interfering with the wheat crop.

All tillage operations in close proximity to the terrace ridge should be parallel to it. A tool which

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Terraces producing sorghum, and cotton growing in the point-row interval. A "through" of Sudan covers the turn-row space in the point-row interval.

2.

leaves a furrowed and cloddy surface should be used. After the ridge is completed, weeds should be killed, following the rains, by using a shovel-type implement which will not reduce the cloddy surface effect before planting.

Harvesting with the terrace, especially where the cross section of the terrace is steep, offers advantages. A cleaner job of cutting on the ridge is expected when the combine follows the terraces—breakage of harvesting machinery often results when the steep and narrow terraces are crossed. A 20-foot combine has been used effectively in harvesting the broad-base wheatland terrace. Stubble should be left as high as possible when combining or when harvesting a row crop that has been grown on terrace ridges. This will help to prevent the ridge from washing in the event that it over-tops, and will reduce the irregularity of accumulations or removals on the ridge by wind erosion.

After the terrace ridge has been constructed the problem of its maintenance is forever with us, and care should be taken at all times to prevent the ridge from working down. A good practice in ridge maintenance is to plow the dirt toward the middle of the ridge and allow all possible litter to be worked into the ground in and adjacent to the ridge. Wing plows and disks are good implements for this purpose. An occasional treatment with a blade often makes for effectiveness in the cultivation and maintenance of the terrace ridge.

The terrace interval, from a practical point of view in soil and moisture conservation, should be considered as a small field or a "land." The first problem then is to determine the crop or crops to be planted within this small field between each two terraces. If more than one crop is to be produced, the arrangement of the pattern should be decided as early as possible. This facilitates efficient seedbed preparation and proper row arrangement—the direction and arrangement of rows and drill furrows play an important part in encouraging the water to go into the ground where it falls, and in reducing the concentration above the terrace ridge.

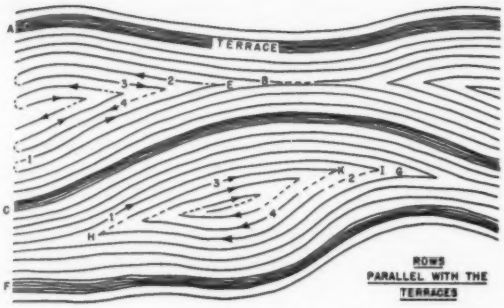
If a drill crop is to be used and if sorghum has been planted on the terrace ridge, in preparing the seedbed the implements may travel around the "land" made by each two terraces, especially if the equipment is old-type and a little difficult to turn. This process of working rows and furrow slices from each side of the "land" will finally work out the irregular interval at mid-point between the two terraces. If modern equipment is available and a general-purpose tractor is used, the seedbed preparation may be backward and forward from one terrace until mid-point between the two terraces is reached. Then move over to the other terrace and work backward and forward until the last long row from this side meets the last one from the other side. Plow out the irregular interval by taking a "through" off first the one side of the triangular "land" and then the other, turning right and left and leaving a three-cornered, unplowed space between "throughs" on the center line between terraces, which can be plowed out

Terraced ridge growing broadcast sorghum, with interval to cotton being cultivated parallel to ridge.

3.

by a finishing round or "through." Implements that leave a cloddy surface with furrows are desirable, especially where the soil is deficient in organic material. Chisels, listers, and shovels have their respective places in this type of seedbed preparation.

Weed control is an important item and should be considered with the timeliness of tillage operations. Where plowing with shovel-type implements immediately follows a rain, little moisture is lost from weed growth and a rough surface to reduce soil blowing can be maintained.

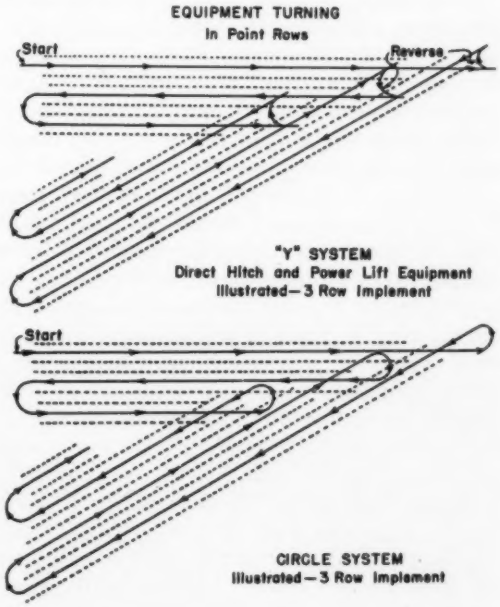


Seeding operations should be closely associated with the amount of moisture in the soil at seeding time and the quantity of residue in and on the ground. Falling rain soaks into the soil more rapidly where the furrows made by grain drills are run parallel with each terrace or level. Deep and semi-deep furrow drills seem to be more advantageous than the surface drill for this particular purpose; likewise, they appear to be beneficial in checking the drifting snow. Some farmers prefer to take the interval between two terraces as a "land" for seeding purposes, while others prefer to drill backward and forward away from each terrace until they have reached the half-way distance between the two and then work out the irregular intervals in a "land," double drilling across the corners.

It seems advantageous to harvest the grain in the same direction in which it was drilled. If acreage between each two terraces has been used as a "land," it may be combined in the same way. Some farmers claim that little difficulty is encountered in crossing drill furrows with the combine if the furrows are of the flat-surface type and are not crossed at right angles. It is desirable at harvest time to leave all the stubble possible and at the same time harvest all the grain. Especially is this true from a wind-erosion prevention point of view. The practice of following the combine with the lister where moisture is available, or with the disk or chisel where it is dry, seems to be profitable for early seedbed preparation.

Where row crops are to be used in the terrace interval, it is best to determine the amount of each, and at the same time the balance between fibrous-rooted and tap-rooted crops, and between fibrous-rooted crops that are to be harvested in the bundle as forage and those, such as milo, which are to be harvested as grain crops. From a soil- and moisture-conservation point of view, it is extremely important that the rows be run parallel to each terrace. The time of bedding, listing or chiseling may vary with the soil type, locality and rainfall, but in any case it should be deep enough to secure a cover of loose dirt over the bottom of the furrow. Soil drifting usually is in proportion to the amount of vegetation on the ground. Where early listing is necessary and weed growth prevails some farmers re-bed the land, while others plow, harrow or knife the beds.

If the crop arrangement is determined soon after the field is bedded, it will be easier to prepare the land for planting when the different planting dates and seasons arrive. Sorghum and cotton, when moisture is available, may not be planted at exactly the same time. They are planted in the furrow and cultivated with a knife or shovel, by much the same method. Enough cultivation to prevent weeds from using the moisture necessary to the development of vigorous normal crop plants is about all that is necessary. The omission of a final late cultivation allows an early fall grass and weed cover on some of the fields; this cover prevents soil blowing and does not materially reduce crop yields.



Methods of harvesting row crops naturally fall into two groups: First, hand harvesting, as picking or snapping cotton and heading maize; and second, machine harvesting, such as binding forage sorghum, combining milo, or field chopping of silage. It is important that machine-harvested crops be cut high enough to leave a stubble that will serve as a barrier to break up the ground sweep of the wind; or that properly spaced alternate strips of high-stubble row

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crops are used with those that may leave a low stubble. Lack of moisture may sometimes reduce the height of bundle feed to such an extent that it is impossible to bind the crop and at the same time leave the desired stubble height. If the farmer needs the feed he will be likely to cut this stubble low and then run a chisel, about 10 inches deep, between each row before the blow season starts.

Beans, cotton, and potatoes are harvested by methods which do not leave sufficient trash on the ground to prevent wind erosion. With these crops we must depend upon the sorghum family, in strip-crop patterns, to help in holding the soil on the fields.

Unless the best known methods are used in managing the irregular intervals between terraces the farmer often has considerable difficulty in working them into his farm operations. It is not always a simple matter to determine the proper land use for these irregular tracts. Farmers themselves vary on this point. Farmers in the cotton section have no objection to working these point rows in cotton, milo, or Sudan. The crop is planted and cultivated in much the same manner as is used when laying in the point rows at the time of preparing the land. The methods used in turning the machinery in the point rows will vary with the different types and makes of implements. With the all-purpose tractor, it appears easy to turn right and left and plow point rows of very short length. If some forage sorghum is required on the farm, it is not at all difficult to use the point row interval as a supplement to a protective strip of row crops. In this case, the desired number of long rows of forage sorghum might be planted adjacent to point rows of milo or cotton and serve to break up the wind current and help in reducing wind erosion across the cotton strip. These intervals are also used as an acreage in which small grain is planted as a protective strip, although there is some objection to the extra turning of the grain harvesting equipment. Some farmers dislike to turn grain binders or forage binders in point rows and prefer planting such intervals to milo or to cotton where hand harvesting is practiced.

Where native perennial grass can be established on the land, or where hay is adaptable, these irregular spaces may be diverted into permanent buffer strips and supply a part of the hay needs for the farm. Where moisture is available such crops as alfalfa or sweetclover may properly occupy these spaces. One governing factor in determing the kind of crop to be planted in the irregular or point row intervals and the total width of this crop, is the distance between terraces in combination with the kind of crop planted on the terraces, especially if the strips in such intervals are intended to be effective in reducing water and wind erosion between terrace ridges.

Crop yields from areas using level terraces are interesting. The results of terracing experiments at Goodwell show that an increase of 4.39 bushels of wheat was secured from the plots during the period from 1926 to 1931 inclusive.

Data from the experiments at Spur show that in 1927 the seed cotton yield was 169 pounds greater on areas having closed terraces than on the area having open end terraces; it was 233 pounds greater in 1928. The field, which was diked and terraced by the syruppan system of diversion terraces, produced 441 pounds of seed cotton in 1928 or 88 pounds more than the average yield of the four areas using open end terraces.

Studies on the Dalhart Soil Conservation Service project reveal the following concerning crop yields on all soils except sandy types: On 20 terraced fields there was an average production of 723 pounds of grain sorghum per acre; 21 contoured fields produced an average of 589 pounds per acre; 7 fields with straight rows produced an average of 461 pounds per acre.

Observations of wheat yields for 1937 from the Soil Conservation Service project located at Vega, Tex., indicate that one field, terraced previous to the spring rains on fallowed land, produced 18 buhsels per acre; 6 fields terraced after the spring rains on fallowed land produced 6.9 bushels; 12 fields terraced after spring rains, following a crop, yielded 2.2 bushels; 20 fields, contour drilled on fallow land, yielded 9.25 bushels; 13 fields, contour drilled after crop, produced 2.8 bushels; 7 fields, straight row drilled on fallow, produced 7.6 bushels; and 24 fields, straight row drilled after crop, yielded 2.2 bushels.

AVAILABLE BY SUBSCRIPTION

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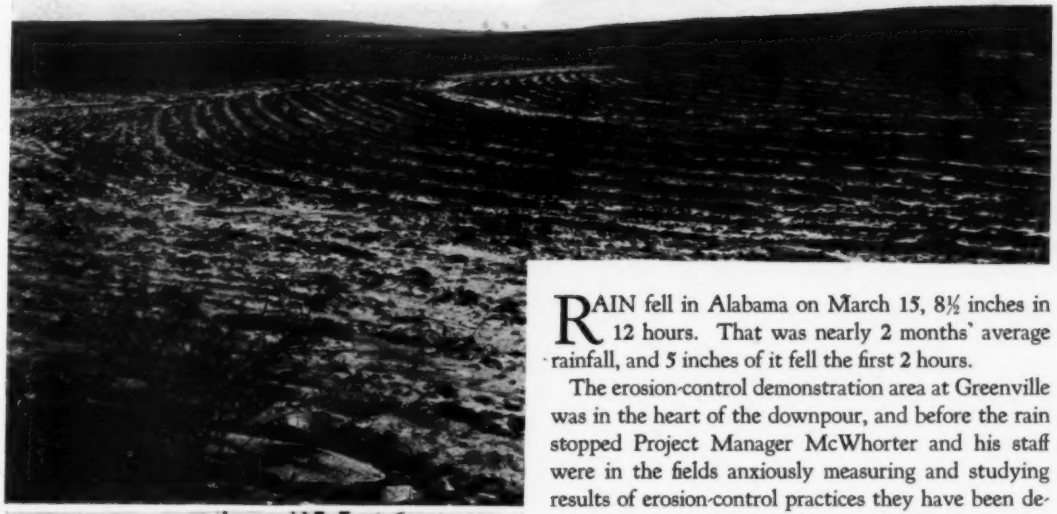
RAIN FELL IN ALABAMA

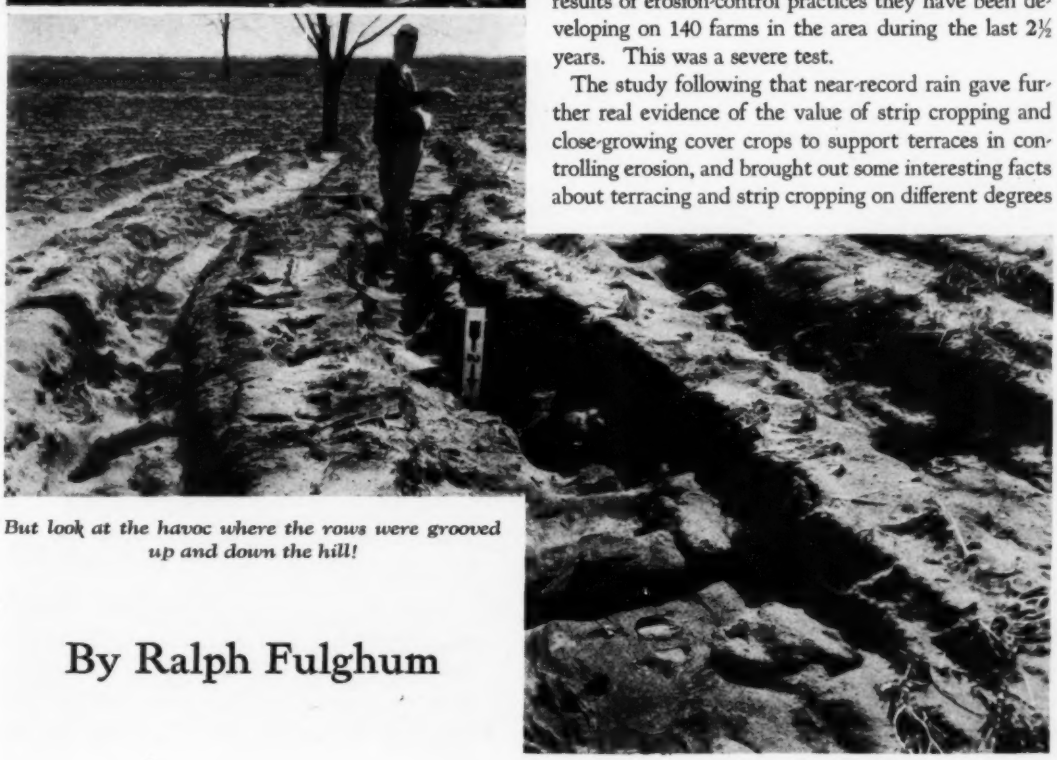
Contour listing and good terraces checked the damage in this field.



RAIN fell in Alabama on March 15, 8½ inches in 12 hours. That was nearly 2 months' average rainfall, and 5 inches of it fell the first 2 hours.

The erosion-control demonstration area at Greenville was in the heart of the downpour, and before the rain stopped Project Manager McWhorter and his staff were in the fields anxiously measuring and studying results of erosion-control practices they have been developing on 140 farms in the area during the last 2½ years. This was a severe test.

The study following that near-record rain gave further real evidence of the value of strip cropping and close-growing cover crops to support terraces in controlling erosion, and brought out some interesting facts about terracing and strip cropping on different degrees



But look at the havoc where the rows were grooved up and down the hill!

By Ralph Fulghum

Terrace interval covered with oats showed very little sanding. Picture taken below strip of oats.

Companion picture taken above strip of oats. Sanding in terrace channel below interval lacking vegetation. Interval contour bedded.

of slope. We present some of those facts here as observations—to point them out rather than to interpret them as final conclusions.

To check the value of strip cropping and close-growing vegetation, soon after the rain the staff examined about 15,000 feet of terraces below strips of close-growing vegetation, and about 15,000 feet of terraces on the same soil type but below bare terrace intervals. They found three times as many rills in the bare terrace intervals, twice as many breaks per mile, and twice as many sandbars or deltas in the terrace channels below the bare intervals as in those below the close-growing strips, as shown in the table.

[All soil Akron fine sandy loam with 37 or 337 erosion class]

Slope	Treatment	Total length of terraces checked	Number of terrace breaks per mile	Number of rills halfway through terrace interval per mile	Number of sandbars or deltas in terrace channel per mile
		Feet			
0 to 5 percent	Cover	6,300	5	27	21
	No cover	6,125	10	46	28
5 to 10 percent	Cover	8,900	3	25	15
	No cover	9,200	8	117	52
Total or average	Cover	15,200	4	26	18
	No cover	15,325	9	81	40

The table shows that there were more terrace breaks per mile on the more level or 0- to 5-percent slope than on the 5- to 10-percent slope. Probably that is because the terraces were built on a variable vertical interval basis and the terraces were much closer together on the steeper slopes.

Also note that on the 0- to 5-percent slopes there were 27 rills per mile (indicating sheet erosion) in the covered terrace intervals compared with 46 rills per mile (not quite twice as many) in the bare intervals. The difference on the steeper or 5- to 10-percent slopes was far greater, there being nearly five times as many rills in the bare intervals as in those covered with close-growing vegetation. This indicates that while strip cropping with close-growing vegetation reduces erosion on the more level land it is even more necessary on the somewhat steeper slopes to check rills and sheet erosion between the terraces.

A good cover of Austrian winter peas. No damage here, although serious erosion occurred on nearby fields.

The project engineer also made a further study of terraces on different slopes, with and without cover in the intervals above. He started at the crest of 100 terraces in each of three slope classes—50 terraces below strips of oats or vetch or winter peas, and 50 terraces below bare terrace intervals—and measured the distance to the first break in the terraces. The following table gives the results:

Slope	Number of terraces broken		Percentage of terraces broken		Average distance to first break	
	Cover	No cover	Cover	No cover	Cover	No cover
0 to 5 percent	12	27	24	54	933	450
5 to 10 percent	20	35	40	70	580	360
10 percent and more	20	28	40	56	430	393

This study also shows that close-growing vegetation in the interval above greatly reduces the number of breaks in the terrace, but it is also evident that the

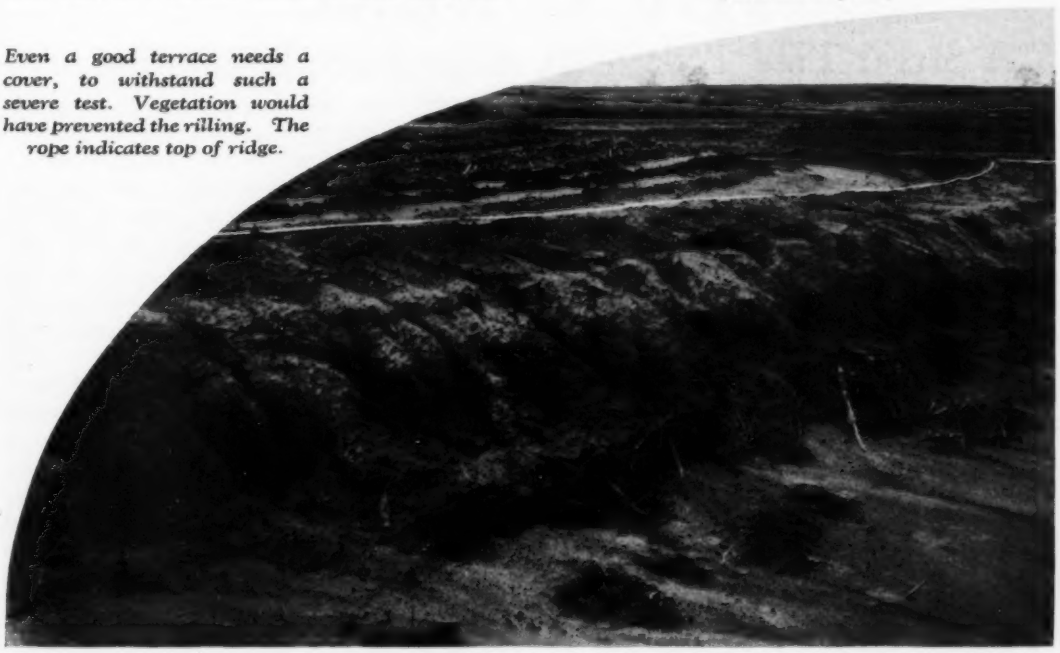
Oats afforded valiant protection to the back and lower sides of this terrace. Severe drainage was suffered by the uncovered land above.

difference between the number of breaks in terraces below close-growing strips and those below bare intervals diminished as the slope increased. This again, no doubt, was due to the fact that the terraces were built on a variable vertical interval basis, and thus the terraces were much closer together on the steeper land and had a smaller total volume of water to carry.

A little further figuring will show that vegetation

(Continued on p. 124)

Even a good terrace needs a cover, to withstand such a severe test. Vegetation would have prevented the rilling. The rope indicates top of ridge.



A ginkgo sprout produced in fifth year after cutting of log. Foliage is vigorous, fully developed.

THE GINKGO

A Street Tree Today—A Hillculture Possibility of Tomorrow

By S. B. Detwiler[1]

THERE is need to develop new uses for tilled lands which must be taken out of cultivation to control soil erosion. Such areas are best planted to trees. Often, however, the farm owner needs a larger and earlier return than can be secured from timber and as a consequence of this there is now interest in trees and shrubs which can be developed for special economic products, such as food, waxes, oils, and insecticides, or for high-priced specialty woods.

Ginkgo is but one of many perennial plants worthy of special study to determine their erosion-control and economic possibilities for annual production of new products from leaves and fruits, and having a value for specialty wood when the crop-bearing years are ended.

[1] Head, section of hill culture research, division of research, Soil Conservation Service, Washington, D. C.

The ginkgo or maidenhair-tree has the reputation of being more resistant to damage from insects and diseases than any other well-known shade or street tree. It is noted for its long life; the ability of ginkgo logs to produce vigorous water-sprouts 6 years after cutting is additional evidence of exceptional vitality in this tree.

Where the ginkgo trees grow on banks and slopes, the roots appear to hold the soil well, and this quality along with fairly rapid growth, freedom from pests, and hardiness as far north as eastern Massachusetts and central Michigan, indicates that it may have potential value as a specialty tree for erosion-control planting.

Ginkgo was introduced into the United States by William Robert Prince, son of the founder of the oldest nursery in America, established in 1737 at

Flushing, Long Island, N. Y. Between the close of the Revolutionary War and 1803, the Princes sought plants from every corner of America and Europe, and introduced nearly all of the Japanese trees we know, including ginkgo. The oldest ginkgo tree in the United States long shaded the old Prince homestead in Flushing. It came from Japan via England.

The curious leaves, odd fruit and individualistic branching habits of the ginkgo are so different from those of other trees of the yew family that its relationship to them is seldom suspected by the uninitiated. It has beautiful leaves resembling those of the maidenhair fern but much larger in size. The chief use of the ginkgo in the United States has been as a specimen tree, planted by tree-lovers as a unique and picturesque botanical curiosity. It has not been used for forest and economic purposes.

In recent years it has been planted in Washington, D. C., and some other cities as a street tree. Much of its popularity for this purpose is due to the beauty of the famous avenue of ginkgo trees, planted about 1872, which led from the old red-brick Department of Agriculture building on the Mall to Constitution Avenue at Thirteenth Street, in Washington. A remnant of this beautiful avenue still remains, although most of the trees were cut in November 1931, preliminary to the leveling and formalized planting of the Mall between the Capitol and the Washington Monument.

The logs from these trees, about 50 in number, were piled high within a shed which has its sides open to free circulation of air, and they have not been disturbed since they were stored there in 1931. In 1935 one of these logs, separated from contact with the ground by intervening logs for a distance of 4 feet, sent up a vigorous sprout from its side. This sprout attained a length of over 2 feet by the end of 1935 growing season. In the same year another log in this pile produced a sprout over a foot long. J. Wise Byrnes, superintendent of greenhouses in the Bureau of Plant Industry, called the writer's attention to this interesting phenomenon and the logs were kept under observation.

Early in the 1936 growing season a log near the top of the pile and over 5 feet above the ground sent forth vigorous shoots at three different places along its side. One of these sprouts was photographed on July 13, 1936. Two other logs in the pile, one on the ground and one 6 feet above ground, produced similar sprouts in 1936. These were different logs from those which bore sprouts in 1935. In 1937 three other logs scattered through the pile in the shed again sent up sprouts—6 years after the trees were felled. These were not so tall and vigorous as were the sprouts of the preceding year.

The retention of sufficient sap in the ginkgo logs to enable them to sprout in the sixth season after cutting, despite the fact that they were sheltered from rain over the entire period, indicates that the wood seasons very slowly. This also is shown by the absence of any large seasoning-checks at the ends of the logs. That there is considerable shrinkage of the wood during seasoning is well illustrated by a small cross-section of a log which was cut when the ginkgo trees were felled in November 1931, seasoned in a warm dry room for 6 months, and which since then has been on display in Mr. Byrnes' office. In expectation that the thin section of log would check and split, it was tightly encircled with an iron band after it had been dried out over winter. This precaution proved unnecessary. While a distance of approximately an inch now separates this iron band from the top of the log section, this decrease in size has come about so slowly that no checks have developed.

Dr. Woon Young Chun in his book, Chinese Economic Trees, states that "although generally regarded as native only in China, *Ginkgo biloba* is not now certainly known to be aboriginal or truly wild in any part of the country. It has been reported by Meyer as growing spontaneously in Chekiang Province, where it was cut for firewood, but others doubt it is truly spontaneous there. On account of sentimental attachments, the tree is not often cut down, and the wood therefore seldom finds its way in the market. The wood is soft, but straight grained, light brownish in color with a silky sheen. It is used for making abacus beads, seals, and other small fancy articles. In Japan it is extensively used for the ground work of the lacquer ware. The Japanese use the leaves for fertilizer, especially in rice fields under water. They ascribe to the leaves an insecticidal power. A leaf of the Ginkgo used as a bookmark will keep away insects that attack books."

The wood is entirely free from resin. It takes a smooth finish and polishes readily. The Chinese use this wood for carving, for which it appears to be as well adapted as sugar pine, a wood often used for this purpose. While apparently slightly harder than white pine wood, it has a fine, even grain that resembles "pumpkin" pine.

Lee B. Robertson, of Arlington, Va., made a test of ginkgo wood for pattern making and found it satisfactory for this purpose. He writes:

> For 13 years I was a pattern maker at the United States Navy Yard at Washington, D. C., and am therefore familiar with the

common woods used in pattern making, mostly white pine, but also cherry and mahogany, and occasionally redwood. I consider white pine the best wood for patterns in the above list. Judgment must be based upon soft grain and easy working, freedom from shrinking and warping, smooth finish, and ability to hold well when glued and take shellac well. White pine represents the highest standard in all of these respects.

I made two patterns from the ginkgo wood; one was turned on a lathe and the other was all made by hand. This represents the two ways in which patterns are ordinarily made, and my object was to give this new wood a severe test. Except for a noticeable difference in odor of the wood and a slightly darker color, I found no difference in the ginkgo wood from that of the best white pine. Had I not been advised that I was working with a new kind of wood, I would not have suspected this wood was other than the white pine. Judging by this small but careful test, and based on my long experience with pattern-making woods, I consider the ginkgo wood fully equal to the white pine for this purpose.

Both the Chinese and Japanese grow the ginkgo for its seeds, esteemed by them as an appetizer and digestive aid or as a delicacy when lightly roasted. The seeds are sold in the markets of all Chinese towns and the meat resembles dried almonds except that it has a somewhat fishy flavor. In Japan, the seeds furnish an oil used for cooking and burning. It is probable that oriental markets would consume larger quantities of these seeds if they were obtainable, but the supply in China and Japan is limited.

The seed is the size of a large plum pit, with a thin shell. Its exterior is covered by a thick pulp having an aroma strongly offensive to American nostrils; the wood also has some of this unpleasant odor when freshly cut. The kernel is free of this odor and is rich in an oily substance which may possibly have commercial uses. It is reported that some of the workmen in Washington have suffered from swollen glands for several days after collecting the fruits from the trees on the Mall. This poisoning affects only certain individuals, as does poison ivy. Those who object to planting ginkgo trees on account of its fruits can plant grafted staminate trees, since this species is dioecious.

A search of Chinese literature disclosed a reference in the Chinese Encyclopedia of 1726 to the effect that the ginkgo was first entered as tribute in the Sung dynasty (A. D. 960–1271). The name then was changed to silver apricot but it was not used for medical purposes until about A. D. 1700, when "medical prescriptions sometimes use it. It can kill insects (worms?) and dispel poisons. If much is eaten it causes oppression and swelling."

Scientists regard ginkgo as the oldest genus of trees now surviving from past ages. Evidence of ginkgo trees has been found in rocks of the period (Permian) that followed the Coal Age, and in a later period several species of ginkgo grew with Liriodendron and Glyptostrobus to form forests covering most of the Northern Hemisphere. Perhaps the ability of this tree to survive through the vast changes of long geologic ages, and its resistance to attack, are due to unsuspected chemical properties. Studies of the chemical and wood properties of ginkgo may prove productive.

In the Dutch East Indies a system of "bergculture" (hillculture) has been developed for annual production of specialty crops from trees and shrubs. Erosion is controlled and fertility of the soil built up under this system of maintaining natural and planted shrubby ground covers and leguminous trees which lightly shade and protect the crop trees. The latter are improved in quality and yield of products through breeding and selection, as in horticulture. The work of the section of hillculture research aims to develop erosion-resisting plants of economic value as an aid to the success of the national erosion-control program. This work is done in cooperation with the responsible Federal and State subject-matter agencies and aims to develop better erosion-control plants and their better use, including methods for a modified hillculture system adapted to conditions in the United States. This section encourages systematic cooperative studies of the ginkgo and similar erosion-resisting plants having potential economic value.

RAIN FELL IN ALABAMA

(Continued from p. 121)

above the terrace channel reduced the number of terrace breaks 66 percent on the 0- to 5-percent slopes, 43 percent on the 5- to 10-percent slopes, and 29 percent on the 10-percent and steeper slopes.

Likewise, vegetation above the terrace interval increased the average distance to the first break in the terraces 52 percent on the 0- to 5-percent slopes, 38 percent on the 5- to 10-percent slopes, and 9 percent on the slopes that were 10-percent and steeper.

After the rain farmers over the area seemed convinced that terracing alone would not control erosion. With one accord, the dozen or more farmers I talked with said they did not like strip cropping when they started it but that now they wish they had strip cropped more of their farms. Strip cropping in the area was done by terrace intervals, and possibly would have been even more effective had the strips been astride the terraces.

FRESNO TERRACES. *By Fred C. Newport*[1]

Enrollees at Memphis C. C. C. camp demonstrate terrace construction with four-up team and a 5-foot fresno. They are using the "circle" system.

IN the United States, the application and efficient use of farm power and farm implements, supplemented by economic "dirt moving" machines, has been attempted by farmers in building soil conserving structures. The plow, the disk, the V-drag, the ditcher, the slip, and the grader, alone or in various combinations, have all contributed to the modern terrace construction of today.

The art of constructing terraces with a fresno is not new and seems to have wide application in certain portions of the Cotton Belt. Communities in Arkansas and Texas have used the fresno for the construction of satisfactory farm terraces. Especially is this true among owner-operators and renters who have had previous experience in moving dirt with this type of implement and who either keep hired help or do most of their own farm work. Many farmers find the fresno useful in constructing such additional farm improvements as (1) stock-watering places, (2) trench silos, (3) diversion structures, (4) levees, and (5) foundations for buildings. Sizes of fresnos adaptable to the power units used on the farm are procurable through local hardware dealers at small cost.

Fresno terracing may have evolved from the early use of fresnos to make fills in a bladed-terrace ridge. R. E. Dickson, superintendent of the experiment station at Spur, Tex., used fresnos to build his "sirup pan" system in 1926. The Soil Erosion Service built fresno terraces in Arkansas in 1934. The writer demonstrated fresno terraces in Hill County, Tex., from 1924 to 1934, and developed two systems of construction, the "figure 8" and the "circle" system. (See sketches.)

[1]Agronomist, Soil Conservation Service, Amarillo, Tex.

Tricks of the trade in constructing fresno terraces are:

1. Backfurrow two parallel strips the proper distance from each other to make the desired terrace base width. The plowed strips must be wide enough to fill the bowl of the fresno and push a little loose dirt in front of the cutting edge before it reaches the furrow at the border of the unplowed terrace core.

2. Drive at right angles across the plowed strips and load the fresno while approaching the unplowed strip. Loading on a circle may cause the traces or tugs to rub the hind legs of the team.

3. Unload the fresno on the same line at each side of the terrace core to make the curves smooth and the width uniform.

4. Dump each load of dirt snugly against the previous one and avoid gaps or low places in the ridge between dumps.

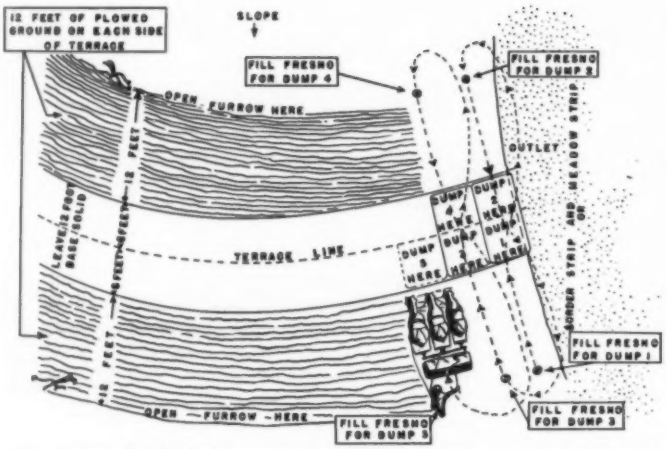
5. Set the fresno so that it loads and unloads easily—about the third hole from the bottom.

6. Dump the fresno while it is moving.

7. Plow the ground close enough to break up all land streaks. Remove stumps, boulders, and other obstacles on the strip to be fresnoed and thus avoid possible accidents.

Power and Labor Costs

Farmers who have built terraces with a fresno have estimated that a man with a team, plow, and fresno can complete as many hundred feet of terraces in a working day as there are feet of cutting edge on the fresno. Assuming that this estimate is approximately correct, one man with two good mules and a 30-inch fresno would complete 250 feet of terrace, while one man with four good mules and a 5-foot fresno would complete 500 feet of terrace daily. If the same terrace


12 FEET OF PLOWED GROUND ON EACH SIDE OF TERRACE
SLOPE
FILL FRESNO FOR DUMP 4
FILL FRESNO FOR DUMP 2
OPEN FURROW HERE
OUTLET
TERRACE LINE
FILL FRESNO FOR DUMP 1
FILL FRESNO FOR DUMP 3
OPEN FURROW HERE
FILL FRESNO FOR DUMP 5

"Figure 8" system in diagram. Start plow 6 feet out from terrace line. Throw soil toward terrace line. Plow a strip 12 feet wide. Leave open furrow on outside of broken ground. Hook to fresno and start filling on the lower open furrow. Pull uphill straight across plowed ground and dump on lower side of unbroken strip (dump 1). Keep following the arrows. Mules always will be on solid ground when pulling uphill.

cross section, finished by contract with heavy equipment, cost $30 a mile, the farmer could figure on about $1.40 a day as wages for himself and two-mule team, or about $2.80 a day for himself and four-mule team while terracing at home. In areas where large terrace cross sections are necessary, their construction with a fresno may require almost twice as much time.

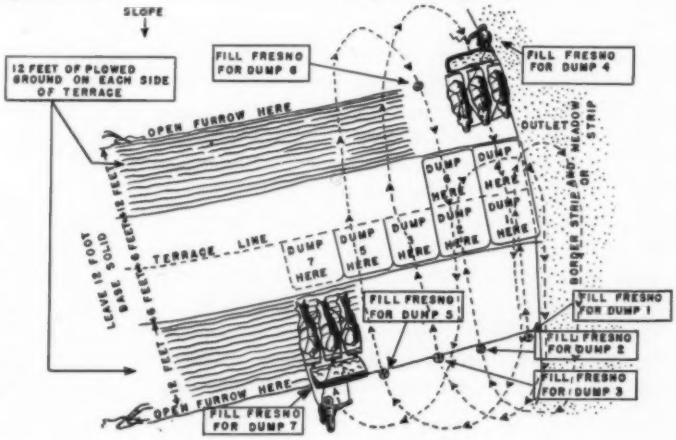
The use of dual-purpose farm tractors will require three men to operate a fresno efficiently in terrace construction where the fields are large and smooth, one to drive the tractor and the other two to load and dump the fresno. With this type of construction a mile of terrace should be constructed in much less time. A well-organized tractor crew has been known to deliver a load of dirt into the terrace ridge in 15 seconds under favorable conditions. The crew was using an all-purpose farm tractor and a 4-foot fresno and following the "figure 8" system in sandy loam soil.

Two pieces of chain about 18 inches to 3 feet long, depending on the make of tractor, or two pieces of rod iron of similar length with an eye in each end, should connect each pull rod on the fresno with the drawbar of the tractor. This is to facilitate loading and unloading and to reduce the possibility of the Johnson bar striking the driver when the fresno is dumped. To ensure greater skill in operating the unit, the spliced pull rods should be fastened to the tractor drawbar about 6 inches closer together than the inside width of the fresno bowl.

Advantages of Fresno Terraces

The larger tractors with machines designed especially for terrace construction usually give the most economical results, but some farmers find it difficult to pay for terrace construction with this type of equipment. The main advantages of terrace construction with fresno scrapers are twofold: The farmer may use his own time, power, and equipment, and the cash outlay is small. If the farmer is willing to devote the extra

(Continued on p. 128)


SLOPE
12 FEET OF PLOWED GROUND ON EACH SIDE OF TERRACE
FILL FRESNO FOR DUMP 6
FILL FRESNO FOR DUMP 4
OPEN FURROW HERE
OUTLET
TERRACE LINE
FILL FRESNO FOR DUMP 5
FILL FRESNO FOR DUMP 1
FILL FRESNO FOR DUMP 2
FILL FRESNO FOR DUMP 3
OPEN FURROW HERE
FILL FRESNO FOR DUMP 7

'Circle system" in diagram. Start plow 6 feet from terrace line. Throw soil toward terrace line. Plow a strip 12 feet wide. Leave open furrow on outside edge of broken ground. Hook to fresno and start filling in on the lower open furrow. Pull uphill straight across plowed ground and dump on lower side of unbroken strip (dump 1). Keep following the arrows, continuing to circle to right, keeping lower side of terrace levee two dumps ahead of the upper side. Mules will be on solid ground when pulling uphill.

BOOK REVIEWS AND ABSTRACTS

By Phoebe O'Neall Faris

TO HOLD THIS SOIL. By Russell Lord, Soil Conservation Service. United States Department of Agriculture Miscellaneous Publication No. 321. Washington, D. C. September 1938.

This book was written especially for the Soil Conservation Service and is intended for circulation throughout the Nation. Mr. Lord is a noted author and a fine writer—and he loves the land probably as few people love it. And furthermore he knows the land and he has at his fingertips many ingenious schemes of writing which he has used to give us the story as written "on the face of the earth," of migration and land exploitation in this country. Most ingenious of all, Mr. Lord tells *from the beginning* what can be done and is being done to heal the scars of the progression of migrations. Conservation is woven into the tapestry of the story, for story it is, and after you have read it you will feel the scope of the problem as never before.

As this review is written the book is not many days off the press, yet already there is much enthusiastic talk about it from all sides. It is being stressed particularly as extremely important in the educational work of the Service: It should go into the schools; grade teachers should use it for background studies and in weaving soil conservation into nature studies, civics, and geography; high school students are going to read every word and then ask for more; economic geographers in colleges and universities will find concise information on every phase of the subject. All this, yes. And why not the land owners and farmers of the country? Who else but the people on the land, this very year and day, should have in their hands a book which gives so striking a picture, all of a piece, in an easy flowing style of writing, of their own country and their own farms? One can see the farmer and his family, under the lamplight of winter evenings, reading through from "The Film of Life" to the end of "Back of Yonder," deeply interested and thoughtful. And then with a new dawn one can see that farmer family out in the field, in the orchard or the vineyard, or the potato patch, looking for the telltale signs, the rills, the bare slope, the silted corn patch, deciding then and there that something is going to be done about it.

The "Maryland window" turns out to be a device with inspiration behind it; for here we have a starting point—Russell Lord sitting at a window of his own farmhouse, gazing out upon his own and his neighbors' fields—green fields and complacent people. They do not have accelerated erosion—so they think! But Russell Lord put on his hat and went out to see. He found silted streams and ponds. He found abandoned acres. And then he took trains or planes and went farther afield, very far afield, all over the United States; and now we have this book (written, most of it, between trips, at that Maryland window), giving the picture and the story of the whole broad sweep of the land as it suffered and winced under an unguided and slashing agriculture throughout the many years, and of that same broad land as it responds to farming practices designed to heal a badly scarred "film of life."

The opening section of the book tells us the difference between geologic and accelerated erosion and why soils go dead under "man-handling." Then, briefly, by means of the time-lapse camera device we are told the story of earth in the making, of balance by means of verdure and soil building, of animals crawling out of the sea on to the land, of man who came along "at noon on December 31st," of glaciers over the land and glaciers receding from the land. Then the picture of the continent as the white man found it—and we are ready to be told of land transformation, at the hand of the white man, during the last four or five seconds of the last day of earth's 757-million-year year. Swiftly and brilliantly then the book moves onward to tell the tale of the exploitation of natural resources in the United States: Of the harvest of fish and fur in the Northeast; of the death of nine-tenths of the trees; of tobacco and cotton in the South and the loss of 7 to 15 inches of topsoil in the Piedmont; of burned-off second growth forest; of deficiency diseases of plants, animals, and even human beings. Is this the beginning of decadence? What else can it be—unless we bestir ourselves?

We then come to the "Wests," and westward treks following "the way of the grass." The people used up the East and went west to take the midlands, leaving in their wake ruined slopes and soiled streams with here and there relics of futile and haphazard attempts at soil and water conservation.

And here we begin to encounter the wealth of historical information which helps to make a living book. Into the meadowy bluegrass country went the western migration; into the prairies; into the 700 million acres of the range. By 1830, three and a half million "Men of Western Waters" lived west of the eastern mountains. They used the natural resources with lavish waste and carelessness. Corn and hog, wheat, cotton, the railroads—what did it matter? The High Plains were there, farther west.

It is in this part of the book that the work of the Soil Conservation Service is definitely introduced. As the reader is guided along the roads of the Wests, he is told of practical methods that have been initiated and are now being forwarded in the attempt to undo the damage so that we may start all over again with new systems of land use and land management. The story of the beginnings of soil conservation is told by projects. We move about over the face of the country—from a "depletion experiment" in Ohio, across the Big River to Columbia, Mo., where the first erosion check plots were laid off on the slopes of the agricultural experiment station in 1917. Then we go into Iowa and learn what Jay N. Darling did about it after hearing Thomas McBride's lectures. And then we come to the Big Creek watershed demonstration area at Bethany, Mo., one of the first in the Nation. The restoration of Coon Valley, on the driftless area of Wisconsin makes a moving story as told by Mr. Lord, "* * * where quail doubled and pheasants quadrupled in the first year of the project."

The next West is the High Plains. And here is an extremely vivid word-picture of the taking of that vast land where rainfall is the most important thing in the world, where grass, if there is any, "hugs the soil." Cattle and more cattle, sheep and more sheep; wounded grass; the plow in the Plains; free land, hardship and violence; wealth; the wheat rush in 1914—40 million acres added to the tilled domain; wheat surplus and a country turned upside down; dust storms, not lesser but greater. At this point Mr. Lord pauses in his story of migrations to tell us that wind erosion is spectacular when it kicks up dust storms, and floods when rivers get out of their banks; but steady persistant erosion, by water and by wind, through wrong land use, is most harmful of all. And that the great dust storm of May 11, 1934 served an invaluable purpose—"It jolted the United States awake to what is happening."

As for westward migration, Mr. Lord strongly emphasizes what

many of us know—it is still going on. Between 1930 and 1937, forty thousand families left the Plains for the Northwest, riding not in covered wagons but in rattling flivers. They left the Great Plains "in bad shape," needing new crops, grass, and more grass, new methods of farming to store the rainfall in the soil.

Then the "Last Wests." This part of the book tells many a tale of the people. There is the story of the pioneer farmer-rancher in northern Colorado who is "tacking around cautiously from old-time ranching to putting up hay and laying in reserve feed * * * 'Taking it along easy; that's what does it. This speculation and plunging, it don't count.'" And there are the farmers at the Mankato projects of the Service, out in Kansas: They had half ruined their land in 20 years and wanted to fix everything up in 20 months; they wanted something striking, and they got expensive broadbase terracing which woke them up to contours. One likes Russell Lord's description of the agrostologists, with noses to the ground, knowing that "grass is immortal" if you know enough about it to appreciate it. But of course, "you can't eat grass" as Mr. Lord reminds us; and he swings into the sorghum, strip-cropping, water spreading, rough cloddy cultivation theme and gives us extraordinarily human accounts of cautious, careful work at the dry-land experiment station at Hays, Kans., and of the Huron, S. Dak., farm-conservation project where the wind blows from this or that direction all the year round. The people are learning how to subdue erosion, to store water in the soil, to hold down their soil and at the same time raise crops so that they need not learn to eat grass—or dust. There is a great deal about dust in the "Last Wests" part of the book—and a very broad picture, too, of the work of the Soil Conservation Service in and around the Dust Bowl.

And then we come to "Back of Yonder"—the land of the Navajo, the Gila gone mad, the far shore where "irrigated citrus groves planted on contour terraces, and terraced, irrigated cropland in some of the fabled valleys of California are probably as little subject to erosion as farm land anywhere." The end of the Oregon Trail is the end of "Back of Yonder" and out there at the very end of things they have learned how to control sand dunes with wheat straw "whiskers" and dunegrasses which "seem to resist any amount of adversity."

In his very brief conclusion Mr. Lord tells us that "the idea of this publication is not to fix or to direct opinion but to arouse it." In which case, the purpose of the book is fulfilled one thousand-fold. The pictures themselves tell a great story.

Mr. Lord's significant new book "Behold Our Land," the monthly selection of the Scientific Book Club, will be reviewed on this page in December.

Flood Control on Watersheds

The work of the soil conservation districts in erosion control is very closely and intimately related to the work which needs to be done on watersheds in aid of flood control, through run-off and water-flow retardation and soil erosion prevention. In fact, in many areas the measures which need to be taken for effective erosion control—terracing, contour farming, forestation, seeding and planting of sloping lands to plants, trees, and grasses—are the identical measures needed to achieve "run-off and water-flow retardation and soil erosion prevention" in aid of flood control. It follows that, just as it has been found necessary to provide for the organization of soil conservation districts which can supplement and extend erosion control operations, so is it equally necessary for soil conservation districts to supplement and extend the work which the Department is authorized to do on watersheds in aid of flood control.—Statement by Secretary Wallace, October 29, 1938.

A technical article listed for December publication is Basil M. Bensin's "Agroecology as a Basic Science of Soil Conservation."

FRESNO TERRACES

(Continued from p. 126)

time required for fresno construction, he can secure satisfactory terraces. Any power available on the farm, such as steers, mules, horses, or small tractors, can be used in constructing fresno terraces.

This type of terrace construction has another advantage on farms where the available power and labor is not required during certain seasons. A more economical use of the farm power and labor can be secured by arranging the terrace construction work at a time when the available power would otherwise be idle. Greater use of animal power on farms also encourages the use of a larger acreage of erosion-resisting feed crops and this usually results in better soil-conservation practices.

WILLOWS FOR STREAMBANK CONTROL

(Continued from p. 111)

banks shade the water, tending to lower the temperature and to increase fish food, and also furnish splendid coverts and travel lanes for wildlife. These advantages together with the fact that willow matting has been used successfully at a cost that compares favorably with other types of protection, should earn for it wider consideration.

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